Sub-seasonal Forecasting Systems at Environment Canada

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Outline

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  - Current operational extended and long-range prediction systems at EC
- **The new experimental sub-seasonal prediction system based on the Global EPS**
  - System design
  - The reforecast (hindcast) strategy
  - Computational aspects
  - Preliminary comparison with current operational monthly prediction system based on CanSIPS
  - Products
  - Data availability
  - Future plan

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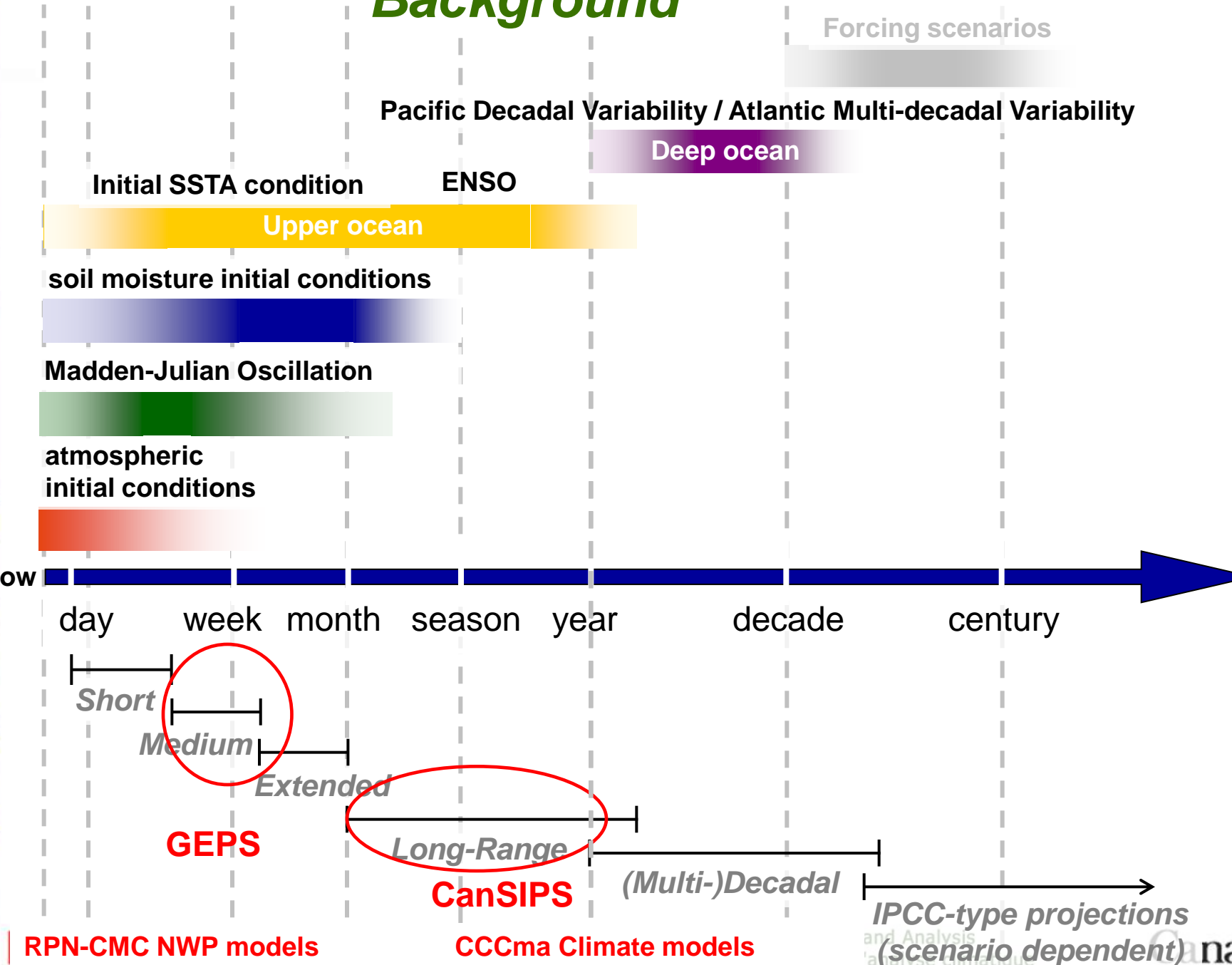
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Background

- Current operational extended and long-range prediction systems

    - **GEPS** (week 1 & 2)
        - 20 GEM model members
        - IC produced by ENKF, no lagged IC
        - 50 km horizontal resolution
        - Not coupled with ice-ocean model
        - Contribute to NAEFS

    - **CanSIPS** (monthly and seasonal) ;
        - 20 members (2 CCCma climate models, 10 from each)
        - IC produced using Incremental Analysis Update (IAU), no lagged IC
        - 300 km horizontal resolution
        - Fully coupled with 3D ice-ocean model
        - Contribute to NMME

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*Not complete

Background

Forcing scenarios

Pacific Decadal Variability / Atlantic Multi-decadal Variability

Deep ocean

Initial SSTA condition   **ENSO**

Upper ocean

soil moisture initial conditions

Madden-Julian Oscillation

atmospheric initial conditions

Sources of Predictability*

now

day   week   month   season   year   decade   century

Forecast Ranges

Short

Medium

Extended

GEPS

Long-Range

CanSIPS

(Multi-)Decadal

IPCC-type projections (scenario dependent)

RPN-CMC NWP models   **CCCma Climate models**

and Analysis
analyse climatique

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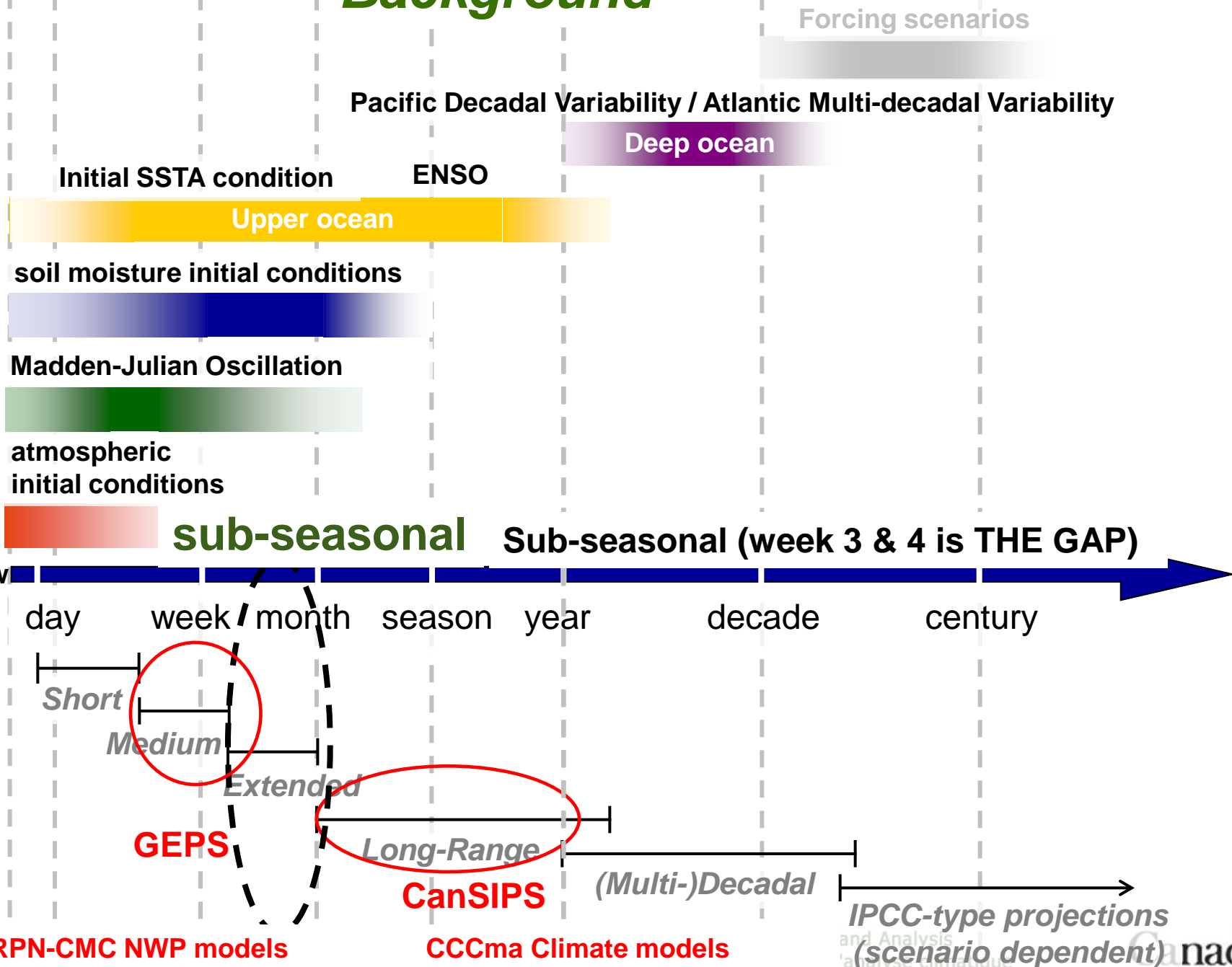
The new experimental sub-seasonal prediction system based on Global EPS

- **System design:**
  - Configuration based on current operational GEPS 4.0.0 used for 16 days forecasts twice a day:
    - GEM model with 50 km grid, 40 levels, top at 2 hPa
    - 20 members, ICs from ENKF (256 members), ICs not lagged
    - Land properties are initialized using real-time CMC analyses
    - Physics perturbations: multi-parametrizations physics, stochastic perturbations of physics tendencies, stochastic energy back-scattering
    - Uncoupled but
      - SST anomalies (averaged of 30-day prior) are persisted
      - Sea-ice is adjusted as a function of threshold of SST
  - **For weeks 3 & 4 purposes:**
    - We extend the forecast to 32 days, once a week (Thursdays at 00Z)
    - We run a reforecast (18 years) on the fly for the corresponding real-time forecast period

The GEPS reforecast (hindcast) strategy

- We do « reforecast » with GEPS mainly to generate:
  - Climate (average and standard deviation) for monthly forecast (32 days)
  - Climate for Extreme Forecast Index calculation
  - Calibration of the forecast probabilities to improve upon member counting

- The reforecast is done on-the-fly as in ECMWF (see Hagedorn, 2008)

- Built-in in the GEPS operational suite

Advantages:

  - The model climatology used to compute the anomaly forecasts is always up-to-date

  - The operational GEPS is upgraded frequently, at least once a year. It would be painful to redo each time the reforecast in a R&D

  - The Operations Division monitors the reforecasts on a 24/7

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The GEPS reforecast (hindcast) strategy

- We use 4 members instead of 20 but we use a moving-window of 5 reforecast dates for a better climate variability sampling. This way we use a historical database of 360 reforecasts for each real-time forecast.

These dates are put together to calculate model climate statistics...

Year	June 20	June ...	June 27	July 1st	July 2	July 3	July 4	July 5th	July 6th	July 7th	July ...	July 11	July ...	July 18
2012	4 mem		4 mem	-	-	-	4 mem	-	-	-		4 mem		4 mem
2011	4 mem		4 mem	-	-	-	4 mem	-	-	-		4 mem		4 mem
...	4 mem		4 mem	-	-	-	4 mem	-	-	-		4 mem		4 mem
	mem			-	-	-	4 mem	-	-	-		4 mem		4 mem

...for forecasts of this week in 2013

The GEPS reforecast (hindcast) strategy

- Challenges and approaches for the historical ICs

  CMC doesn't have 18 years of reanalysis neither upper air or surface

  ❖ Atmospheric ICs

  – Rely on ERA-interim reanalysis. Perturbed analyses are generated by introducing homogenous and isotropic perturbations using an algorithm from the ENKF

  ❖ Surface ICs

  – The initial SST and the sea ice cover conditions are the ones used in the ERA-interim project.

  – A 30 years off-line surface prediction system cycle driven by near-surface atmospheric ERA-interim reanalysis and its associated precipitation was used

    ➢ *This proved to be the most sensible and trickiest part of the reforecast configuration project*

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Computational load aspects of the reforecast

- Every week:
  - 4 members X 18 years = 72 reforecasts of 32 days

    This is spread over 6 days of the week. The 7th day is for the real-time forecast

  - 72 reforecasts / 6 days = **12 reforecast runs of 32 days per day** (3 dates x 4 members)

- This equivalent to around **46% of the total cost** of the GEPS forecasts (including monthly forecast and the twice daily 16 days forecasts)

- Reforecast runs are performed by the operations during low traffic hours on the supercomputer

- We run in advance 2 reforecast dates of the 5 dates18-year moving-window (see earlier diagram). This give us 2 weeks of slack to resolve operational issues that may arise with the system before the reforecast is needed for the real-time forecast.

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Preliminary comparison:
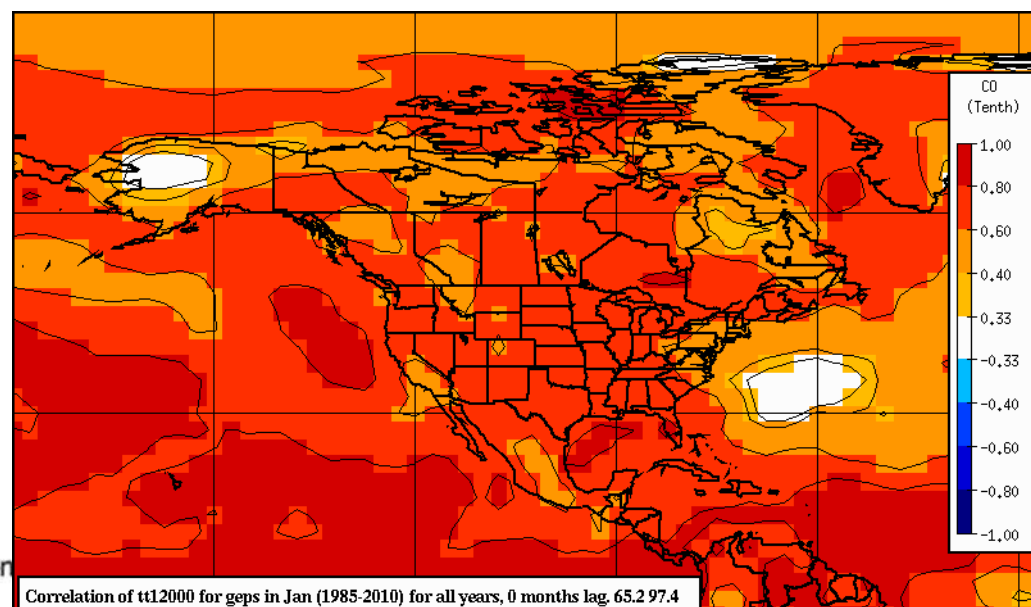## Experimental monthly GEPS vs operational CanSIPS

- Fair comparison using verification over the same reforecast (hindcast) period
    - January (from the 1st to the 31st) reforecasts over 26 years (1985-2010)
    - CanSIPS uses its previously computed hindcast (not on-the-fly)
    - Verification results for July forecasts available soon

- ERA-interim monthly means are used as truth

- Verification scores shown (for 2m temperature only)
    - Serial correlation over the 26 years
    - Percent correct (3 categories; below, near, above)

Serial correlation of T2m (January 1985-2010)

CanSIPS

Correlation of tt12000 for cancm34 in Jan (1985-2010) for all years, 0 months lag. 63.3 95.7

GEPS

Correlation of tt12000 for geps in Jan (1985-2010) for all years, 0 months lag. 65.2 97.4
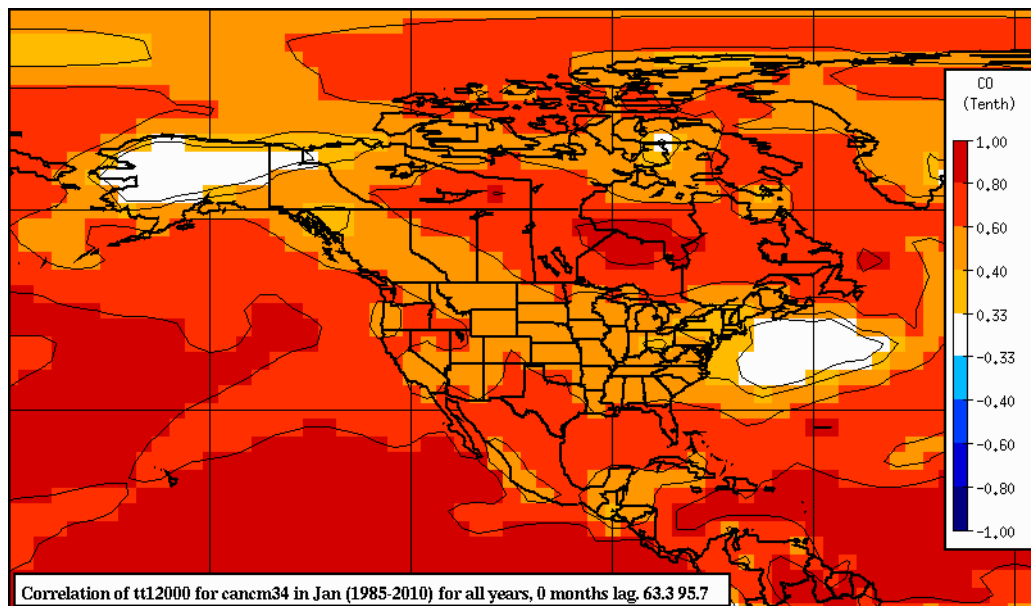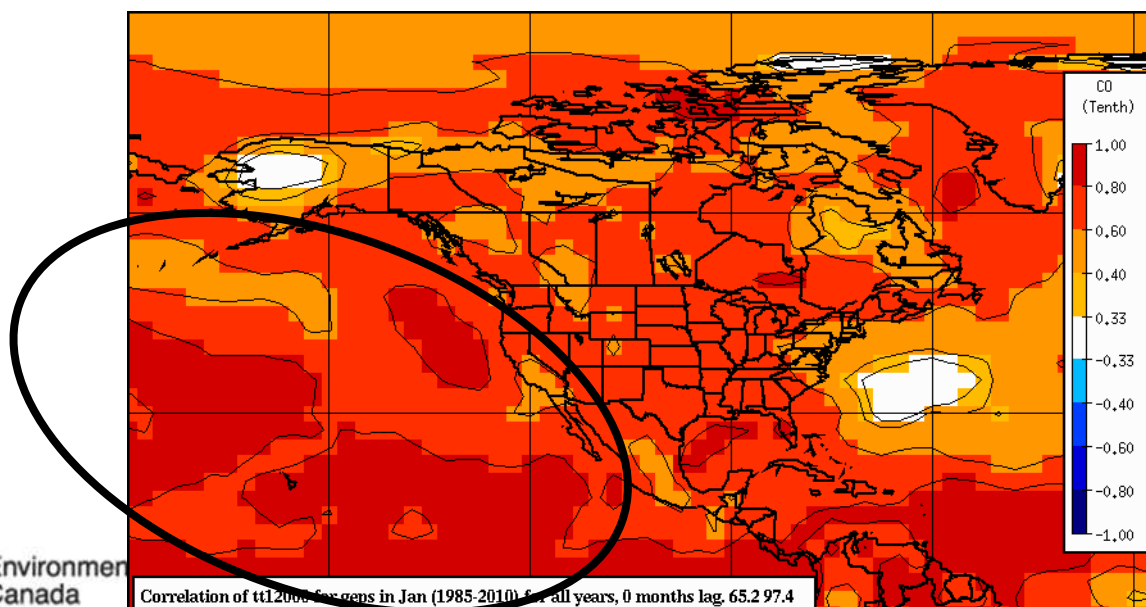
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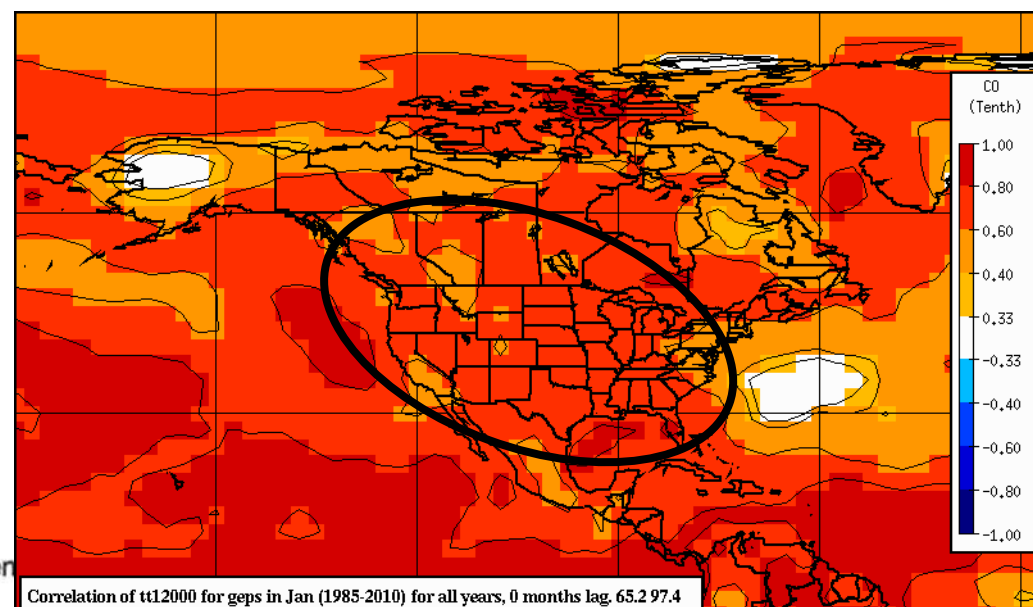# Serial correlation of T2m (January 1985-2010)
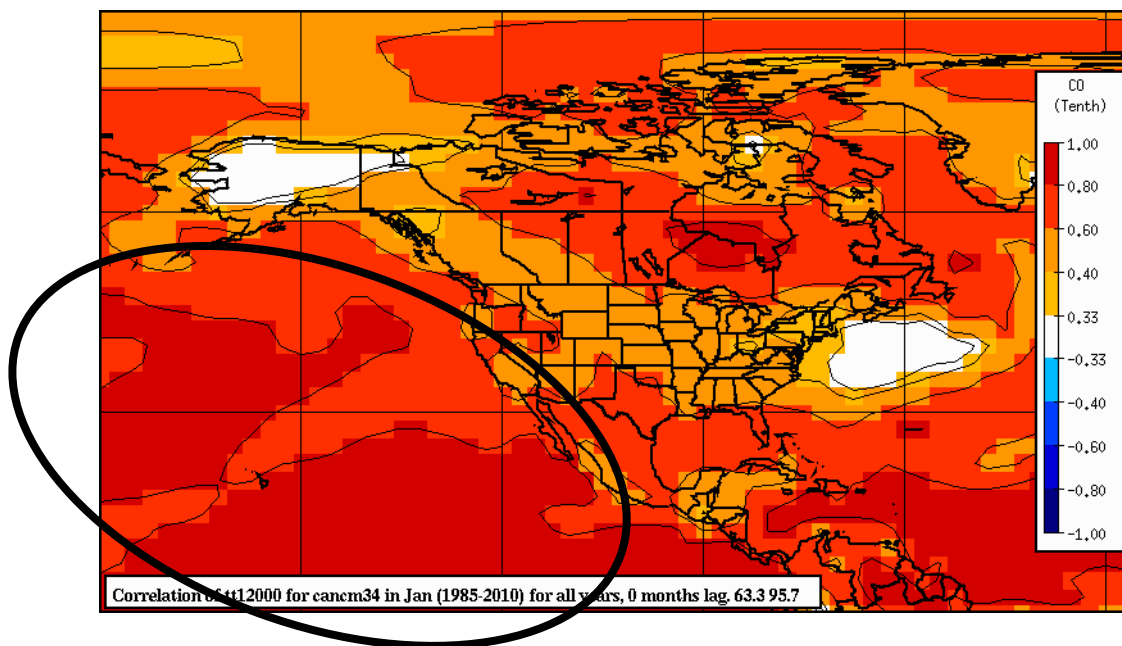
CanSIPS

Better over ocean

GEPS
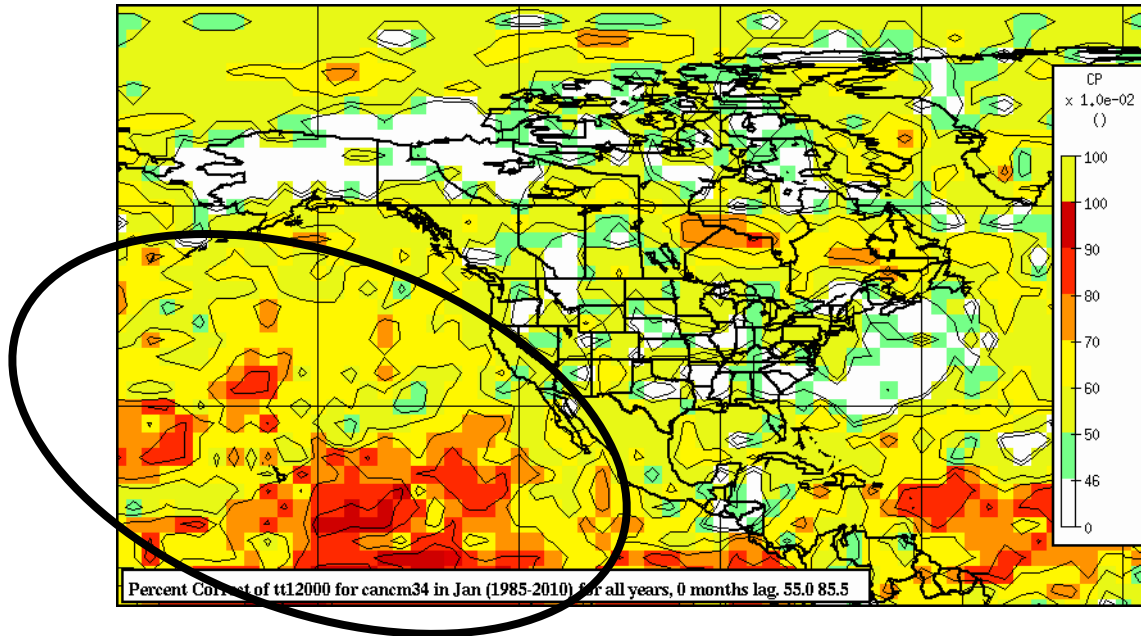
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3 category Percent Correct of T2m (January 1985-2010)

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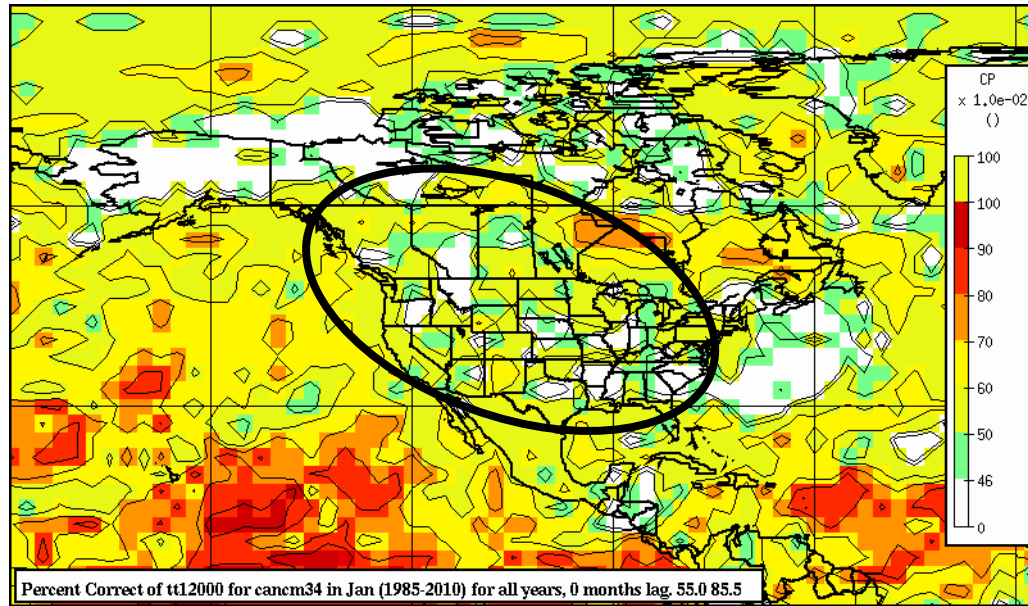

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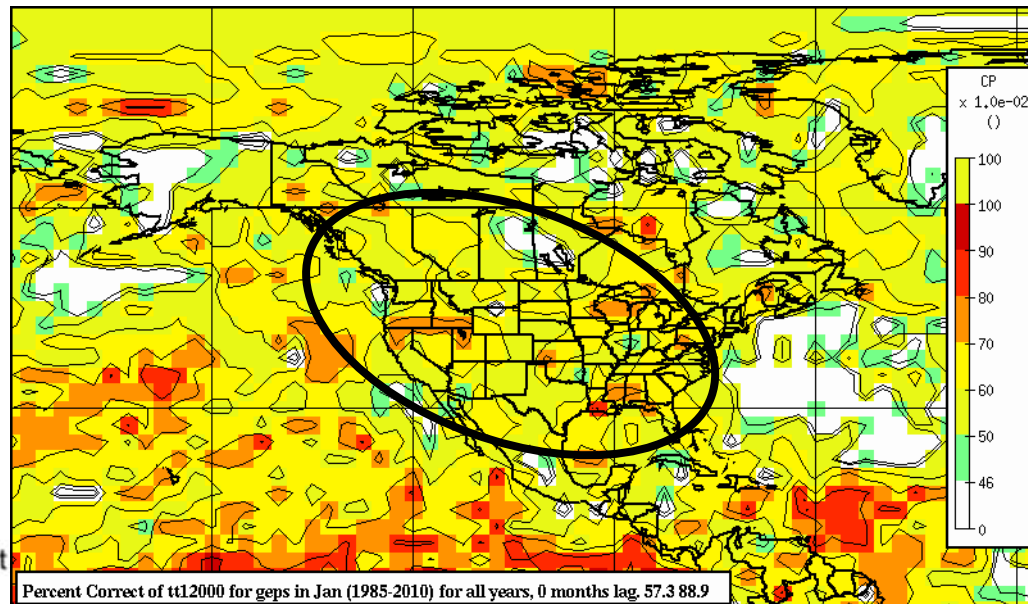
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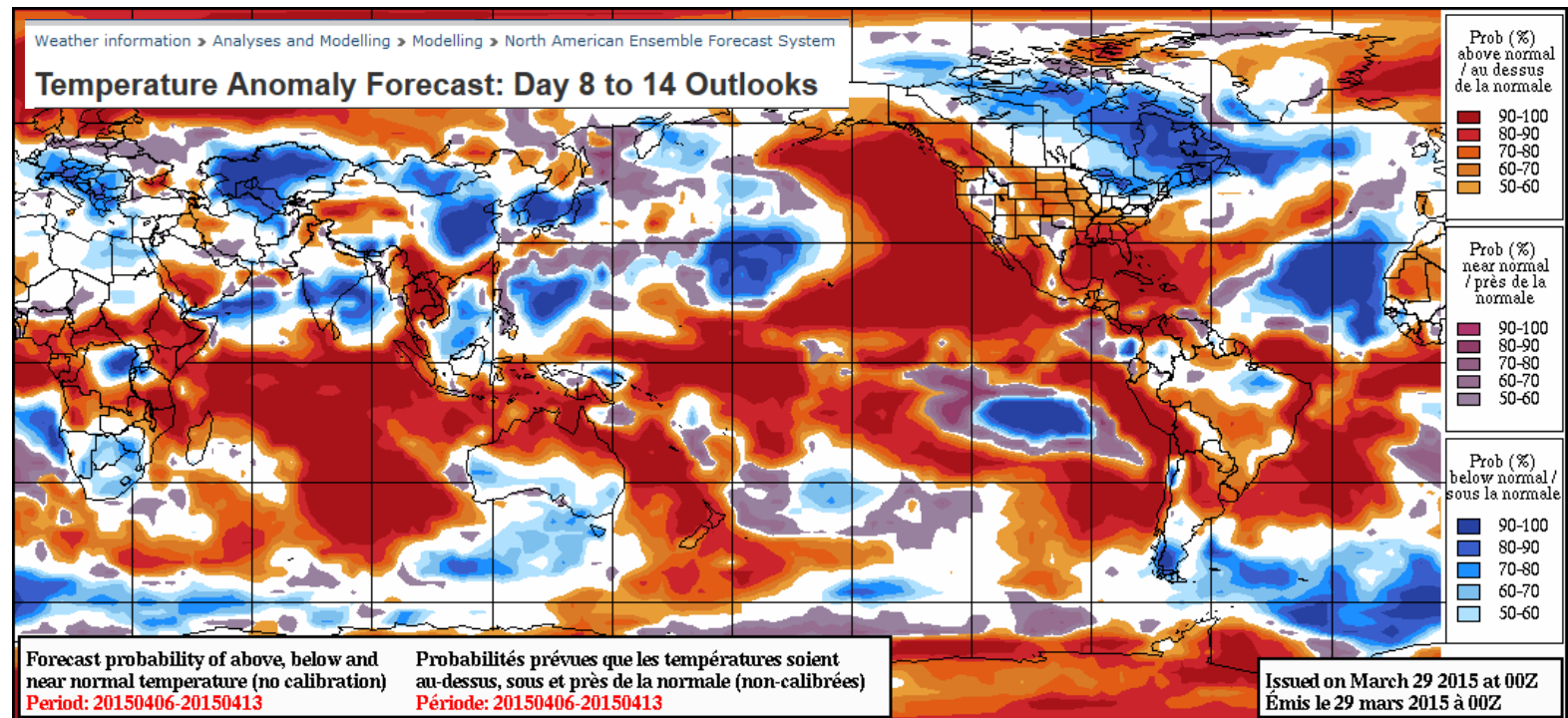
Products

- At first we plan to generalize our NAEFS products currently for weeks 1-2 to weeks 3-4: http://weather.gc.ca/ensemble/naefs/index_e.html

- Extend the application of our Extreme Forecast Index (EFI)
- The range of possible products is huge! A potential gold mine to exploit but that represents a lot of work (calibration, verification & expected skill, many sector of applications)

Data availability

- Almost ready to start contributing to the WWRP/WCRP S2S project data depot at ECMWF

- When officially operational, we plan to put the GEPS monthly forecast and reforecast data output on our public data depot (dd.weather.gc.ca)

- Could eventually contribute to the WMO LRF MME for the sub-seasonal timescale

- Could be part of a sub-seaonal NMME project and/or the NAEFS data exchange

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Future plan

- Produce extensive reforecast verification following WMO standard verification system approach as much as possible and make the results available

- Complete comparison GEPS vs CanSIPS

- Switch the official production of monthly forecasts from CanSIPS to GEPS

- Make available the forecast and reforecast data (public depot, S2S project, NAEFS, NMME, WMO, etc..)

- Enhance products offering

- Develop probabilistic forecast calibration (including 2nd moment) specific for GEPS week 1,2,3,4

Future plan

- Go from weekly issuance to bi-weekly ?

- Go from 32 days to 45 days ?

- **On the modeling side one of the next most important step for the sub-seasonal timescale is to couple each GEPS member with an ocean model (NEMO)**

Thanks!